Renewable Energy Question #6: How can reliability costs and benefits be assessed and incorporated into an analysis of renewables costs? Has any jurisdiction tried to do so, and if so, how?

While reliability will be defined as maintaining electric service, there are numerous time horizons and components that contribute to keeping the lights on. One measure of reliability, whether generation or delivery, is capacity to serve customer demand for electricity, or "load." Thus, more ways to keep the supply adequate for a given level of demand, or the ability to meet a higher level of load would be recognized as increased reliability. Two of the largest concerns for reliability, and two of the largest fixed costs of the power system, are transmission and generation. Midwest ISO provides analyses of costs and benefits in these two categories. Also, the Union of Concerned Scientists has made a study of the reliability benefits and lowered costs from increasing Michigan use of renewable energy.

1. Transmission

Transmission costs and benefits are assessed by Midwest ISO and discussed with stakeholders. In 2010-2011, Midwest ISO defined and approved a portfolio of transmission upgrades to accommodate generation connections and improve reliability in Michigan and across the MISO footprint. The first package of 17 Multi-Value Projects was described by Midwest ISO as "having benefits in excess of the portfolio cost under all scenarios studied. These benefits are spread throughout the system, and each zone receives benefits of at least 1.6 and up to 2.8 times the costs it incurs." MISO Transmission Expansion Plan 2011, page 1.
https://www.midwestiso.org/_layouts/MISO/ECM/Redirect.aspx?ID=120701

2. Generation

Part of the utility industry assessment of reliability risks is to identify how a single event or disturbance to the normal operations can cause an outage at more than one power plant. The Union of Concerned Scientists has explored the risks to the power supply from droughts that interfere with the use of water for cooling power plants. In nearby states of Illinois and Minnesota, cooling water disruption from hot dry weather has caused 12 power plants to interrupt electric supply between 2006 and 2012. (For more information, see http://www.ucsusa.org/assets/documents/clean_energy/ew3/Infographic-The-Energy-Water-Collision-Fact-3.pdf.)

The Union of Concerned Scientists has released a study of the risks to reliability, and related economic and environmental benefits from increasing the use of renewable energy generation. The latest UCS report describes the economic disadvantage of continued operation of seven coal plants in Michigan, and the savings of over 5 billion gallons of *consumed* water if these plants are replaced with renewable energy and energy efficiency. Fleishman, L and Schmoker, M. 2013 *Economic and Water Dependence Risks for America's Aging Coal Fleet.* Cambridge, MA: Union of Concerned Scientists. April.

The Midwest ISO has also has an explicit process for establishing the reliability benefits of new generation. This involves calculating the Loss of Load Expectation (LOLE) for a specific set of generators and energy demand patterns. The idea is that adding more energy sources increases the probability that there will be enough generated energy when a shortage threatens reliability. An increase in this measure generally follows when additional generator is included, and that increase for the specific generator is the Effective Load-Carrying Capability (ELCC). The MISO uses ELCC for wind and has done so

for 3 years. See this year's report at
https://www.midwestiso.org/Library/Repository/Study/LOLE/2013%20Wind%20Capacity%20Report.pdf

Below is description of the steps for finding the reliability benefits from wind from a U.S. Department of Energy-funded research paper. Milligan, M. and Porter, K. 2005. *Determining the Capacity Value of Wind: A Survey of Methods and Implementation*. Golden, CO: National Renewable Energy Laboratory. http://www.nerc.com/docs/pc/ivgtf/milligan_porter_capacity_paper_2005.pdf

ELCC is calculated in several steps. To calculate ELCC, a database is required that contains hourly load requirements and generator characteristics. For conventional generators, rated capacity, forced outage rates, and specific maintenance schedules are primary requirements. For wind, an intermittent resource, at least 1 year of hourly power output is required, but more data is always better. Most commonly, the system is modeled without the generator of interest. For this discussion, we assume that the generator of interest is a renewable generator, but this does not need to be the case. The loads are adjusted to achieve a given level of reliability. This reliability level is often equated to a loss of load expectation (LOLE) of 1 day per 10 years. This LOLE can be calculated by taking the LOLP (a probability is between zero and one and cannot by definition exceed 1) multiplied by the number of days in a year. Thus LOLE indicates an expected value and can be expressed in hours/year, days/year, or other unit of time.

Once the desired LOLE target is achieved, the renewable generator is added to the system and the model is re-run. The new, lower LOLE (higher reliability) is noted, and the generator is removed from the system. Then the benchmark unit is added to the system in small incremental capacities until the LOLE with the benchmark unit matches the LOLE that was achieved with the renewable generator. The capacity of the benchmark unit is then noted, and that becomes the ELCC of the renewable generator. It is important to note that the ELCC documents the capacity that achieves the same risk level as would be achieved without the renewable generator.

A simpler process for finding the reliability benefits for wind generation is used in PJM. The resulting capacity credit can then be by the asset owner in the PJM capacity market. The capacity credit for wind in PJM is based on the wind generator's capacity factor during the hours from 3 p.m. to 7 p.m., from June 1 through August 31. The capacity credit is a rolling 3-year average, with the most recent year's data replacing the oldest year's data. Because of insufficient wind generation data, PJM has applied a capacity credit of 20% for new wind projects, to be replaced by the wind generator's capacity credit once the wind project is in operation for at least a year.